

WHAT IS CLAIMED IS:

1. A vapor-compression refrigerant cycle system comprising:

a compressor for sucking and compressing refrigerant;

a radiator, provided at a refrigerant discharge side of the compressor, for cooling the refrigerant;

a gas-liquid separator for separating the refrigerant from the radiator into gas refrigerant and liquid refrigerant;

a decompression device for decompressing the liquid refrigerant flowing out of the gas-liquid separator;

an evaporator for evaporating the refrigerant after being decompressed in the decompression device;

a heater for heating the refrigerant;

a liquid pump for supplying the liquid refrigerant in the gas-liquid separator to the heater;

a cooling means for cooling the liquid refrigerant to be sucked into the liquid pump;

an energy recovery unit for expanding the refrigerant flowing out of the heater to recover thermal energy in the refrigerant from the heater; and

a switching means for switching between a refrigeration cycle where the evaporator has a refrigeration capacity, and a Rankine cycle where the energy recovery unit recovers the thermal energy, wherein:

in the refrigeration cycle, the refrigerant is circulated in this order of the compressor → the radiator → the gas-liquid separator → the decompression device → the

evaporator → the compressor;

in the Rankine cycle, the refrigerant is circulated in this order of the gas-liquid separator → the liquid pump → the heater → the energy recovery unit → the radiator → the gas-liquid separator; and

the cooling means cools the liquid refrigerant to be introduced into the liquid pump in the Rankine cycle.

2. The vapor-compression refrigerant cycle system according to claim 1, wherein:

the radiator is connected to the refrigerant discharge side of the compressor through a refrigerant circuit;

the switching means includes a switching member that is disposed in the refrigerant circuit to shut a refrigerant flow from the refrigerant discharge side of the compressor to the radiator in the Rankine cycle; and

the liquid pump is provided to supply the liquid refrigerant to the heater while bypassing the switching member in the Rankine cycle.

3. The vapor-compression refrigerant cycle system according to claim 1, wherein:

the heater is a vapor generator that generates a super-heated vapor refrigerant in the Rankine cycle;

the energy recovery unit includes an expansion device that expands the super-heated vapor refrigerant from the heater in iso-entropy in the Rankine cycle; and

the radiator is disposed to cool and condense the expanded refrigerant in the expansion device of the energy recovery unit in the Rankine cycle.

4. The vapor-compression refrigerant cycle system according to claim 3, further comprising

an inner heat exchanger having a first refrigerant passage through which the liquid refrigerant in the gas-liquid separator is introduced into the liquid pump, and a second refrigerant passage through which the refrigerant decompressed in the decompression device flows, wherein:

before the liquid pump is operated in the Rankine cycle, the switching means is operated to set a start mode where the refrigerant is circulated in this order of the compressor → the heater → the radiator → the gas-liquid separator → the decompression device → the inner heat exchanger → the compressor.

5. The vapor-compression refrigerant cycle system according to claim 4, wherein the liquid pump is operated in the Rankine cycle, after the start mode is performed for a predetermined time.

6. The vapor-compression refrigerant cycle system according to claim 4, wherein the start mode is performed until an amount of the liquid refrigerant in the gas-liquid separator becomes equal to or larger than a predetermined

value, and the liquid pump is operated in the Rankine cycle, after the amount of the liquid refrigerant in the gas-liquid separator becomes the predetermined value.

7. The vapor-compression refrigerant cycle system according to claim 4, wherein the start mode is performed until a super-cooling degree of the liquid refrigerant in the gas-liquid separator becomes equal to or larger than a predetermined value, and the liquid pump is operated in the Rankine cycle, after the super-cooling degree of the liquid refrigerant in the gas-liquid separator becomes the predetermined value.

8. The vapor-compression refrigerant cycle system according to claim 4, wherein:

in the start mode, the refrigerant decompressed in the decompression device is evaporated in the second refrigerant passage of the inner heat exchanger by absorbing heat in the refrigerant of the first refrigerant passage between the gas-liquid separator and the liquid pump, so as to have a cooling capacity.

9. The vapor-compression refrigerant cycle system according to claim 1, wherein the cooling means is an electronic refrigerator using a Peltier effect.

10. The vapor-compression refrigerant cycle system

according to claim 1, wherein the cooling means is a super-cooler that cools the liquid refrigerant from the gas-liquid separator by using outside air.

11. The vapor-compression refrigerant cycle system according to claim 1, further comprising

an additional pump for supplying the liquid refrigerant in the gas-liquid separator into a suction side of the liquid pump.

12. The vapor-compression refrigerant cycle system according to claim 11, wherein the additional pump is disposed in the gas-liquid separator in such a manner that at least a suction port of the additional pump is positioned in the liquid refrigerant in the gas-liquid separator.

13. The vapor-compression refrigerant cycle system according to claim 11, wherein the liquid pump and the additional pump are integrated with the gas-liquid separator.

14. The vapor-compression refrigerant cycle system according to claim 1, wherein the compressor and the energy recovery unit are integrated.

15. The vapor-compression refrigerant cycle system according to claim 1, wherein the energy recovery unit is arranged in parallel with the compressor in a refrigerant flow.

16. The vapor-compression refrigerant cycle system according to claim 1, further comprising

an energy storage means for storing energy recovered by the energy recovery unit.

17. The vapor-compression refrigerant cycle system according to claim 1, wherein the heater heats the refrigerant by using waste heat generated from an equipment mounted on a vehicle.

18. The vapor-compression refrigerant cycle system according to claim 1, wherein the refrigerant contains at least one substance selected from the group consisting of HFC134a, HFC152a, butane, propane, and ammonia, as a main constituent of the refrigerant.

19. A vapor-compression refrigerant cycle system comprising:

a compressor for sucking and compressing refrigerant;

a radiator, provided at a refrigerant discharge side of the compressor, for cooling the refrigerant, the radiator being connected to a refrigerant discharge side of the compressor through a refrigerant circuit;

a decompression device for decompressing refrigerant flowing out of the radiator;

an evaporator for evaporating the refrigerant after being

decompressed in the decompression device;

a refrigerant shutting unit disposed in the refrigerant circuit to shut a refrigerant flow from the refrigerant discharge side of the compressor to the radiator;

a heater for heating the refrigerant;

a refrigerant supply means for supplying refrigerant to the heater while bypassing the refrigerant shutting unit; and

an energy recovery unit for expanding the refrigerant flowing out of the heater to recover thermal energy in the refrigerant from the heater, wherein:

when a refrigeration cycle where the evaporator has a refrigeration capacity is set, the refrigerant is circulated in this order of the compressor → the radiator → the decompression device → the evaporator → the compressor; and

when a Rankine cycle where the energy recovery unit recovers the thermal energy is set, the refrigerant shutting unit shuts the refrigerant flow from the refrigerant discharge side of the compressor to the radiator, and the refrigerant is circulated by the refrigerant supply means in this order of the heater → the energy recovery unit → the radiator → the heater.

20. The vapor-compression refrigerant cycle system according to claim 19, wherein:

the compressor and the energy recovery unit are integrated to form a compressor device; and

the compressor device functions as the energy recovery

unit when the refrigerant flowing out of the heater flows into the compressor device.

21. The vapor-compression refrigerant cycle system according to claim 19, wherein the energy recovery unit is connected in parallel with the compressor.

22. The vapor-compression refrigerant cycle system according to claim 19, wherein the heater is provided in the refrigerant circuit connecting the compressor and the radiator.

23. The vapor-compression refrigerant cycle system according to claim 19, further comprising a gas-liquid separator for separating the refrigerant flowing out of the radiator into gas refrigerant and liquid refrigerant, wherein,

in the Rankine cycle, the liquid refrigerant separated in the gas-liquid separator is supplied to the heater by the refrigerant supply means.

24. The vapor-compression refrigerant cycle system according to claim 19, further comprising energy storage means for storing energy recovered by the energy recovery unit.

25. The vapor-compression refrigerant cycle system according to claim 24, wherein the energy storage means includes a capacitor.

26. The vapor-compression refrigerant cycle system according to claim 24, wherein the energy storage means stores the energy recovered in the energy recovery unit as a mechanical energy.

27. The vapor-compression refrigerant cycle system according to claim 19, wherein the energy recovery unit generates an electric energy by use of the recovered energy.

28. The vapor-compression refrigerant cycle system according to claim 19, wherein the compressor is driven by an electric motor.

29. The vapor-compression refrigerant cycle system according to claim 19, wherein the compressor is disposed to be driven by plural kinds of driving sources.

30. The vapor-compression refrigerant cycle system according to claim 19, wherein the compressor is disposed to be driven by a driving source other than an electric motor.

31. The vapor-compression refrigerant cycle system according to claim 19, further comprising an auxiliary heater that is provided separately from the heater, for heating the refrigerant by using heat of an exhaust gas discharged from a heat engine.

32. The vapor-compression refrigerant cycle system according to claim 19, wherein the heater heats the refrigerant by using waste heat generated by a heat engine.

33. The vapor-compression refrigerant cycle system according to claim 32, wherein the heater heats the refrigerant by using heat of exhaust gas discharged from the heat engine.

34. The vapor-compression refrigerant cycle system according to claim 19, wherein the heater heats the refrigerant by using waste heat generated by equipment mounted on a vehicle.

35. The vapor-compression refrigerant cycle system according to claim 19, wherein the heater heats the refrigerant by use of a plurality of heat sources.

36. The vapor-compression refrigerant cycle system according to claim 19, wherein the refrigerant contains at least one substance selected from the group consisting of HFC134a, HFC152a, butane, propane, and ammonia, as a main constituent of the refrigerant.